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ORIGINAL RESEARCH

DEVELOPMENT OF AN UPPER EXTREMITY 'SWING COUNT' AND PERFORMANCE MEASURES IN NCAA DIVISION I VOLLEYBALL PLAYERS OVER A COMPETITIVE SEASON

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ABSTRACT

Background: Monitoring the volume of activity (i.e. pitch counts) and tracking upper extremity (UE) performance changes is common in overhead athletes; however, a lack of evidence exists for volleyball players.

Purpose: The purpose of this study was to investigate changes in shoulder mobility, strength, and pain, along with UE swing count volume in Division I collegiate female volleyball athletes over a competitive season.

Study Design: Observational, longitudinal study

Methods: Swing count data was collected during two separate days of practice during weeks 1, 7, and 14 of the competitive season. Perceived swing counts were collected after each practice from athletes and two coaches. Actual swing counts were tallied by retrospective viewing of video footage. Dominant shoulder internal (IR) and external rotation (ER) range of motion (ROM) and isometric strength, along with UE pain, were assessed on five occasions: baseline, in-season (weeks 1, 7, 14) and post-season (week 22).

Results: Five Division I female volleyball athletes participated. Perceived UE swing counts among coaching staff were significantly correlated with actual swing count (r = 0.93 - 0.98, $p < .05$), while athlete perceived swing count was moderately correlated and was not statistically significant (r = 0.64, p = .25). Shoulder IR ROM decreased from baseline to week 14 (-5.6 $\pm$ 10.6, 95% CI: -18.76, 7.6; p = .03), with a large effect size (d = 1.0). Large effect sizes were observed for increases in UE pain, shoulder ER ROM, and IR strength (d = 0.8 - 2.3). An increase in shoulder IR strength occurred from baseline to week 14 (p = .001), but decreased during the eight weeks of post-season relative rest (p = .02).

Conclusions: UE swing count estimates by coaching staff demonstrated higher correlation with actual swing counts obtained through video recording, as compared to volleyball athlete self-report. This cohort experienced increased shoulder IR strength and ER ROM over a competitive season. Shoulder IR ROM decreased during the first 14 weeks with a large effect size. Monitoring UE performance changes and swing count volume may have implications for injury prevention and program development for volleyball athletes.

Level of Evidence: Level 2B

Key words: Female, range of motion, shoulder, strength, volleyball

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Financial Disclosures: Brandon Ness is an instructor for a continuing education company and receives honorariums for teaching courses related to sports physical therapy, is in the process of commercializing a rehabilitation measurement device with patent pending, and is the owner of a company which distributes rehabilitation resources.

Kory Zimney is senior faculty with a post-professional educational company and receives honorariums for teaching courses related to pain neuroscience education and has published books related to pain neuroscience education for which he receives royalties.

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DOI: 10.26603/ijspt20190582

INTRODUCTION

Women's collegiate volleyball participation has been rising in recent years, as over 17,000 athletes participated in 2017-2018 as reported by the National Collegiate Athletic Association (NCAA).[1] This trend in increased popularity has also been observed at the high school level in the United States, where over 400,000 high school girls participated in volleyball in 2017-2018 – exceeding participation in other popular sports such as basketball.[2] Common injuries in competitive volleyball participation include those to the ankle, knee, and shoulder, where shoulder strains were the third most common injury experienced during NCAA women's volleyball matches as reported from 1988-1989 through 2003-2004.[3] Time loss from shoulder overuse injuries was the greatest, at an average of over six weeks, when compared to other body regions for Dutch second and third division volleyball players.[4]

Excessive volume of overhead activity has been frequently documented as an upper extremity (UE) injury risk factor in other sports, such as baseball,[5,6] tennis,[7,8] and handball.[9] Particularly with baseball, various governing bodies have put forth position statements to guide the volume of overhead activity in efforts to reduce injury, often referred to as 'pitch counts.' The National Athletic Trainers' Association has supported pitch count recommendations according to age, game/season, and type of pitch.[10] At the present time, similar workload guidelines do not exist for volleyball athletes of any age or ability level, in spite of the knowledge that a competitive volleyball athlete may perform upwards of 40,000 attacks per year.[11] It may prove beneficial to develop a 'swing count' to monitor UE workload in volleyball athletes to develop injury prevention strategies.

Shoulder mobility and strength imbalances have also been identified as risk factors for UE injuries in several overhead sports. A substantial decrease in dominant shoulder IR ROM, as well as total shoulder ROM, were identified as UE injury risk factors in high school softball and baseball athletes.[12] Further, these same softball and baseball athletes who displayed over 25° of IR ROM deficit on the dominant shoulder were at four times elevated risk of UE injury. The associated trend in glenohumeral internal rotation deficiency, decreased total rotational motion, and shoulder injury has also been documented in professional baseball pitchers.[13] Similarly, a prospective study of elite male handball athletes who were at elevated risk for shoulder injuries included those with reduced total rotational motion, external rotation weakness, and scapular dyskinesis.[14] A cohort study of high level male volleyball athletes demonstrated a similar trend, with muscle imbalances of the dominant shoulder linked to increased injury risk.[15] However, little is known about how shoulder mobility and strength imbalances fluctuate, or persist, over a competitive season in elite volleyball players.

In efforts to identify those at risk for shoulder injury, preseason testing has been advocated for overhead athletes. External rotation and supraspinatus weakness, as identified preseason, were significantly associated with a throwing-related injury and surgical intervention in professional baseball players.[16] Serial testing of shoulder strength in swimmers over a competitive season revealed increases in internal rotator:external rotator strength ratios, which may place athletes at elevated risk for shoulder injury.[17] Hence, rehabilitation professionals may be well positioned to participate in preseason, or serial, testing in efforts to design shoulder injury prevention programs for volleyball athletes, despite a current lack of evidence-based preventative intervention studies.[18] The purpose of this study was to investigate changes in shoulder mobility, strength, and pain, along with UE swing count volume in Division I collegiate female volleyball athletes over a competitive season. A secondary purpose was to compare actual versus perceived UE swing counts among athletes and coaching staff.

METHODS

Research Design

This study was approved by the University of South Dakota Institutional Review Board. All subjects signed an approved informed consent form prior to participation. This was a longitudinal research design.

Participants

Division I female volleyball athletes were recruited from a Midwestern university. In order to participate, athletes were required to be female, at least 18 years of age, and active on the women's volleyball team roster (non-redshirt). Subjects were excluded if they reported any previous injury to the back or upper extremities within the prior three months that caused them to miss an entire practice or game, previous surgery to the back or upper extremities within the prior six months, or were pregnant. Subjects were removed from the study if, at any point during the season, injury caused them to miss any practice/game. Playing position was not specifically recorded in this study.

PROCEDURES

UE performance testing began in pre-season and concluded roughly two months post-season, which consisted of dominant shoulder IR and ER ROM, isometric strength, and UE pain level. UE performance measures were attained at baseline (week 0), in-season (weeks 1, 7, 14) and post-season (week 22). Swing count data was collected during two separate days of practice during weeks 1, 7, and 14 of the competitive season, which concluded at week 14. Demographic information collected at baseline included: height, body mass, and age. All testing was conducted in a controlled laboratory environment through a station-based approach, where each participant completed tests in an identical order with the same examiner at each station. Participants were blinded to all UE performance measurements, as well as perceived and actual swing count values reported by other athletes, coaches, and/or researchers.

Range of Motion

Shoulder passive ROM procedures were adapted from a previous study.[19] A towel roll was placed under the distal upper arm to position the fulcrum (elbow) in the coronal plane and in line with the acromion.[20] The shoulder was first abducted 90° in neutral rotation, elbow positioned in 90° flexion, and forearm in neutral pronation-supination. ROM values were obtained using a standard universal goniometer centered on the long axis of the humerus, with the stationary arm positioned vertically and moving arm along the lateral ulna. IR passive ROM was determined when a firm end-feel was noted by the examiner with anterior stabilization at the coracoid process of the scapula (Figure 1). ER passive ROM was performed similarly, and care was taken through manual stabilization of the scapula in order to isolate glenohumeral joint mobility. Total shoulder ROM was defined as the sum of IR and ER ROM.

Figure 1. *Passive Internal Rotation Range of Motion.*

Strength

For purposes of torque calculation, forearm length was measured during baseline testing with the participant in supine and recorded as the distance from the olecranon to the distal ulnar styloid process. A handheld dynamometer (HHD) (microFET2, Hoggan Scientific, LLC. Salt Lake City, UT, USA) was used to assess isometric strength. A chair was placed in two separate doorways, facing the door frame to measure shoulder ER and IR strength, respectively. The chair was then rotated 60° in the transverse plane to place the shoulder in the scapular plane, or 30° from the coronal plane (Figure 2). The examiner placed the individual's dominant shoulder in 90° of scaption and neutral rotation, 90° of elbow flexion, and the forearm in relative neutral pronation-supination to accommodate the HHD force pad. Test position was selected to replicate the sport-specific position of a volleyball hit. Participants were cued to

Figure 2. *Isometric External Rotation Strength Testing with Handheld Dynamometry in the Scapular Plane.*

sit as erect as possible. The HHD was placed against the door frame for enhanced stability, as adding a stabilizing device has demonstrated excellent test-retest reliability when assessing isometric shoulder strength[21] along with eliminating the influence of examiner strength.[22] The HHD was positioned at the dorsal aspect of the wrist, at level of the radial and ulnar styloid processes.[23] Each participant was prompted to provide a gradual build up to maximum voluntary effort and hold for five seconds duration. During initial measurements, one practice trial was allowed to familiarize the participant with testing procedures. Participants were given a 20 second rest period between two test trials. Shoulder ER and IR torque values were calculated using the average of two test trials and forearm length measurements (distance from ulnar styloid to olecranon), then normalized to body mass (Nm/kg). Shoulder strength ratios were expressed as shoulder ER: IR torque.

Pain

A standard numeric pain rating scale (NPRS) was used to determine pain levels experienced by the athletes throughout the season.[24] Participants were asked if they were experiencing pain at any location in the dominant UE (including scapula, shoulder, elbow, wrist, or hand) and rated this pain on a 0-10 NPRS, with 0 indicating no pain and 10 indicating the worst pain possible.

Upper Extremity Swing Count

An educational session was provided to the coaching staff and athletes prior to the first practice, and they were instructed to include all overhead hits, roll shots, and serves when reporting their perceived swing count. Coaching staff and athletes were blinded from each other's perceived swing counts and were advised to not share this information. Perceived swing counts were recorded through paper surveys collected immediately after each practice from the athletes and two volleyball coaching staff members, who were present at all practice sessions. Two practice sessions each week of swing count data collection (weeks 1, 7, and 14) were selected based on team availability and travel schedules. Athletes were instructed to provide an estimated swing count for themselves, while coaching staff provided perceived swing counts for all athletes participating in the research protocol. Athlete and coaching staff self-reported swing counts were averaged according to each individual athlete during each week of data collection, while a season composite swing count was calculated from the mean of the weekly swing counts.

Actual swing count data was collected by means of video recording and analysis. Practices were video recorded by team staff, and viewed by two researchers collaboratively in an environment with minimal distractions. An UE swing was tallied for a serve, attack, or roll shot. One researcher viewed the video footage and called out a swing along with the corresponding athlete's jersey number, while the other researcher recorded the data. Playback speed was modified as needed by the researchers - depending on the intensity of the practice and changing formations. At the conclusion of each viewing session, swing counts were tallied for each athlete.

STATISTICAL METHODS

Statistical analyses were conducted using SPSS version 24.0 (IBM Corp, Armonk, NY, USA). Descriptive statistics, Pearson correlations, and paired t-tests

Table 1. *Average Perceived vs. Actual Daily Upper Extremity Swing Count over a Competitive Season. Values expressed as mean ± standard deviation (95% confidence interval) .*

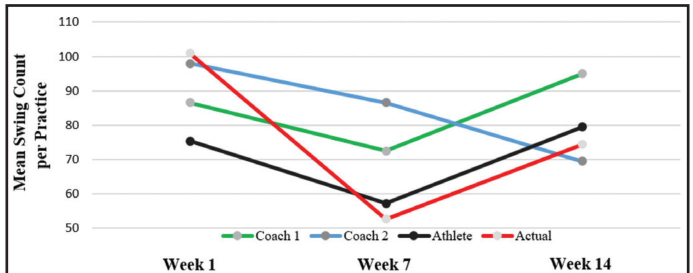
	Week 1	Week 7	Week 14	Composite
Coach 1*	86.5 ± 29.1 (50.4, 122.6)	72.5 ± 34.0 (30.3, 114.7)	95.0 ± 19.4 (71.0, 119.0)	84.7 ± 24.4 (54.3, 115.0)
Coach 2*	98.0 ± 36.5 (52.7, 143.3)	86.5 ± 32.7 (45.9, 127.1)	69.5 ± 12.3 (54.2, 84.8)	84.7 ± 24.1 (54.7, 114.6)
Athlete†	75.4 ± 67.5 (-8.4, 159.2)	57.2 ± 29.4 (20.7, 93.7)	79.5 ± 26.4 (46.7, 112.3)	70.7 ± 35.4 (26.8, 114.6)
Actual	101.0 ± 29.9 (63.9, 138.1)	52.6 ± 28.1 (17.6, 87.6)	74.3 ± 28.2 (39.3, 109.3)	76.0 ± 27.7 (41.7, 110.3)

*Coaching staff provided perceived swing counts for each athlete individually
†Athletes provided a self-reported swing count for themselves only

were utilized. Strength of correlation was determined based on the following guidelines: < 0.25 (weak or no relationship), 0.25 – 0.5 (fair), 0.5 – 0.75 (moderate to good), > 0.75 (good to excellent).[25] Paired t-tests were used to compare dominant shoulder torque, ROM, and pain measures at different points through the season with alpha level for significance set at $p \leq 0.05$. Cohen's d was used to examine effect size by dividing the difference of the means by the pooled standard deviation according to the following guidelines: < 0.2 (trivial), 0.2 – 0.49 (small), 0.5 – 0.79 (medium), and ≥ 0.8 (large).[26]

RESULTS

Five healthy Division I female volleyball athletes completed the testing protocol (age: 19.6 ± 1.1 years, height: 1.8 ± 0.1 m, mass: 79.4 ± 6.6 kg). Mean perceived swing counts (season composite) among coaching staff were significantly associated with actual swing count (r = 0.93 - 0.98, $p < .05$), while athlete perceived swing count was moderately correlated but was not statistically significant (r = 0.64, p = 0.25). Swing count results are further outlined in Table 1, along with graphical depictions in Figure 3 to describe trends of mean perceived and actual swing counts. Table 2 displays dominant UE pain, shoulder ROM, strength, and strength ratios over the course of the season, while Table 3 provides statistical comparisons including t score and effect sizes. Shoulder IR ROM decreased from baseline to week 14 (-5.6 ± 10.6, 95% CI: -18.76, 7.6; p = .03), with a large effect size (d = 1.0). Large effect sizes were observed for increases in UE pain, shoulder ER ROM, and IR strength over the course of the competitive season (d = 0.8 - 2.3). Total shoulder ROM remained relatively consistent from baseline to week 14 (0.0 ± 10.2, 95% CI: -12.7, 12.7). An increase in shoulder IR strength was observed from baseline to week 14 (p = .001), but decreased during the eight weeks of post-season relative rest (p =.02). Finally, ER ROM gains were significantly associated with ER strength loss (r = 0.96, p = .01). Figures 4 and 5 display chronological ROM and strength changes over the competitive season.



*Perceived swing counts are represented by coaching staff and athlete self-report.

Figure 3. *Actual versus Perceived Swing Count.*

DISCUSSION

Subjective rating of workload, traditionally assessed through session rating of perceived exertion (sRPE), is regular practice in other sports such as soccer[27,28] and rugby.[29] A previous investigation utilized sRPE of collegiate volleyball athletes and their coaches as a means to calculate training load, which revealed coaching staff were generally accurate in their perception of sRPE and training load.[30] This is consistent with the results of the current study, where perceived swing count by coaching staff was highly correlated to actual swing count, not to mention the

Table 2. *Dominant Upper Extremity Pain, Shoulder Internal and External Rotation Range of Motion, Total Range of Motion, Shoulder Internal and External Rotation Strength, and External to Internal Rotation Strength Ratios. Values expressed as mean ± standard deviation (95% confidence interval).*

	Week 0 (Baseline)	Week 1	Week 7	Week 14	Week 22 (Post-season)	Season Composite
Pain*	0 ± 0 (0, 0)	1.4 ± 1.9 (-1.0, 3.8)	1.4 ± 1.3 (-0.3, 3.1)	1.4 ± 1.9 (-1.0, 3.8)	0.8 ± 1.2 (-0.6, 2.2)	1.0 ± 0.9 (-0.1, 2.1)
IR ROM†	47.4 ± 10.8 (34.0, 60.8)	45.4 ± 10.5 (32.4, 58.4)	42.6 ± 13.7 (25.6, 59.6)	38.0 ± 7.6 (28.5, 47.5)	41.8 ± 9.7 (29.8, 53.8)	43.0 ± 9.5 (31.3, 54.8)
ER ROM	105.0 ± 10.7 (91.7, 118.3)	106.0 ± 5.5 (99.1, 112.9)	114.0 ± 11.3 (100.0, 128.0)	114.4 ± 13.0 (98.3, 130.5)	114.8 ± 12.3 (99.6, 130.0)	110.8 ± 9.8 (98.7, 123.0)
Total ROM	152.4 ± 11.6 (138.0, 166.8)	151.4 ± 9.4 (139.7, 163.1)	156.6 ± 9.5 (144.8, 168.4)	152.4 ± 15.7 (132.9, 171.9)	156.6 ± 7.3 (147.6, 165.6)	153.9 ± 9.5 (142.1, 165.7)
IR STRENGTH‡	0.22 ± 0.04 (0.17, 0.27)	0.22 ± 0.03 (0.19, 0.25)	0.3 ± 0.06 (0.23, 0.37)	0.33 ± 0.06 (0.26, 0.40)	0.24 ± 0.04 (0.19, 0.29)	0.26 ± 0.04 (0.21, 0.31)
ER STRENGTH	0.21 ± 0.04 (0.15, 0.26)	0.21 ± 0.04 (0.15, 0.26)	0.2 ± 0.04 (0.15, 0.24)	0.21 ± 0.05 (0.15, 0.26)	0.19 ± 0.04 (0.15, 0.24)	0.2 ± 0.04 (0.16, 0.25)
ER / IR STRENGTH RATIO	0.97 ± 0.13 (0.81, 1.13)	0.93 ± 0.14 (0.75, 1.11)	0.94 ± 0.1 (0.82, 1.07)	0.93 ± 0.08 (0.84, 1.03	0.7 ± 0.1 (0.57, 0.82)	0.89 ± 0.08 (0.8, 0.99)

IR, internal rotation; ER, external rotation; ROM, range of motion.
*Numeric Pain Rating Scale, †Degrees, ‡Percent body mass

Table 3. *Paired t-tests comparing dominant shoulder pain, range of motion, and strength measurements across a competitive season. Change score values expressed as mean ± standard deviation (95% confidence interval).*

	Baseline v. Week 14				Week 14 v. Week 22				Baseline v. Week 22			
	Change Score	t	*p*	Cohen's *d*	Change Score	t	*p*	Cohen's *d*	Change Score	t	*p*	Cohen's *d*
Pain†	1.4 ± 1.9 (-1.02, 3.8)	-1.6	0.18	1.4	-0.6 ± 0.8 (-1.6, 0.4)	1.6	0.18	0.4	0.8 ± 1.2 (-0.6, 2.2)	-1.6	0.20	1.3
IR ROM‡	-5.6 ± 10.6 (-18.76, 7.6)	3.3*	0.03	1.0	3.8 ± 6.8 (-4.7, 12.3)	-1.2	0.28	0.4	-5.6 ± 10.6 (-18.8, 7.6)	1.2	0.30	0.5
ER ROM	9.4 ± 12.0 (-5.54, 24.3)	-1.7	0.16	0.8	0.4 ± 5.4 (-6.3, 7.1)	-0.2	0.88	0.03	9.8 ± 8.2 (-0.3, 19.9)	-2.7	0.06	0.9
Total ROM	0.0 ± 10.2 (-12.7, 12.7)	0	1.0	0	4.2 ± 10.4 (-8.7, 17.1)	-0.9	0.42	0.4	1.5 ± 6.0 (-5.9, 8.9)	-1.8	0.15	0.4
IR STRENGTH§	0.11 ± 0.03 (0.08, 0.15)	-8.7*	<0.01	2.3	-0.1 ± 0.1 (-0.2, -0.02)	3.7*	0.02	1.9	0.02 ± 0.1 (-0.1, 0.1)	-0.7	0.5	0.5
ER STRENGTH	-.003 ± 0.02 (-0.03, 0.02)	0.3	0.78	0.1	-0.02 ± 0.03 (-0.1, 0.02)	1.2	0.31	0.4	-0.02 ± 0.05 (-0.1, 0.04)	0.9	0.4	0.5
ER / IR STRENGTH RATIO	-0.04 ± 0.1 (-0.16, 0.08)	0.9	0.42	0.4	-0.2 ± 0.1 (-0.4, -0.1)	5.3*	0.01	2.6	-0.3 ± 0.1 (-0.4, -0.1)	5.6*	0.01	2.3

IR, internal rotation; ER, external rotation; ROM, range of motion.
*Statistically significantly different at $p \leq 0.05$, †= reported as Numeric Pain Rating Scale, ‡= reported in degrees, §= reported as percent body mass

extraordinarily similar mean perceived swing counts between the two coaches. Recording perceived swing counts may be a viable, accessible means to track UE workload in volleyball athletes in order to appropriately monitor and adjust UE workload.

The volleyball swing counts obtained from the current investigation also need to be discussed relative to other sports, such as baseball. The mean actual swing counts varied between roughly 60-100 swings per practice. A separate study using NCAA Division I women's volleyball data identified the combined number of attack and serve attempts for a single game may reach upwards of ten for an outside hitter, so theoretically may require 30-40 per match in a best-of-five competition assuming an average of 3-4

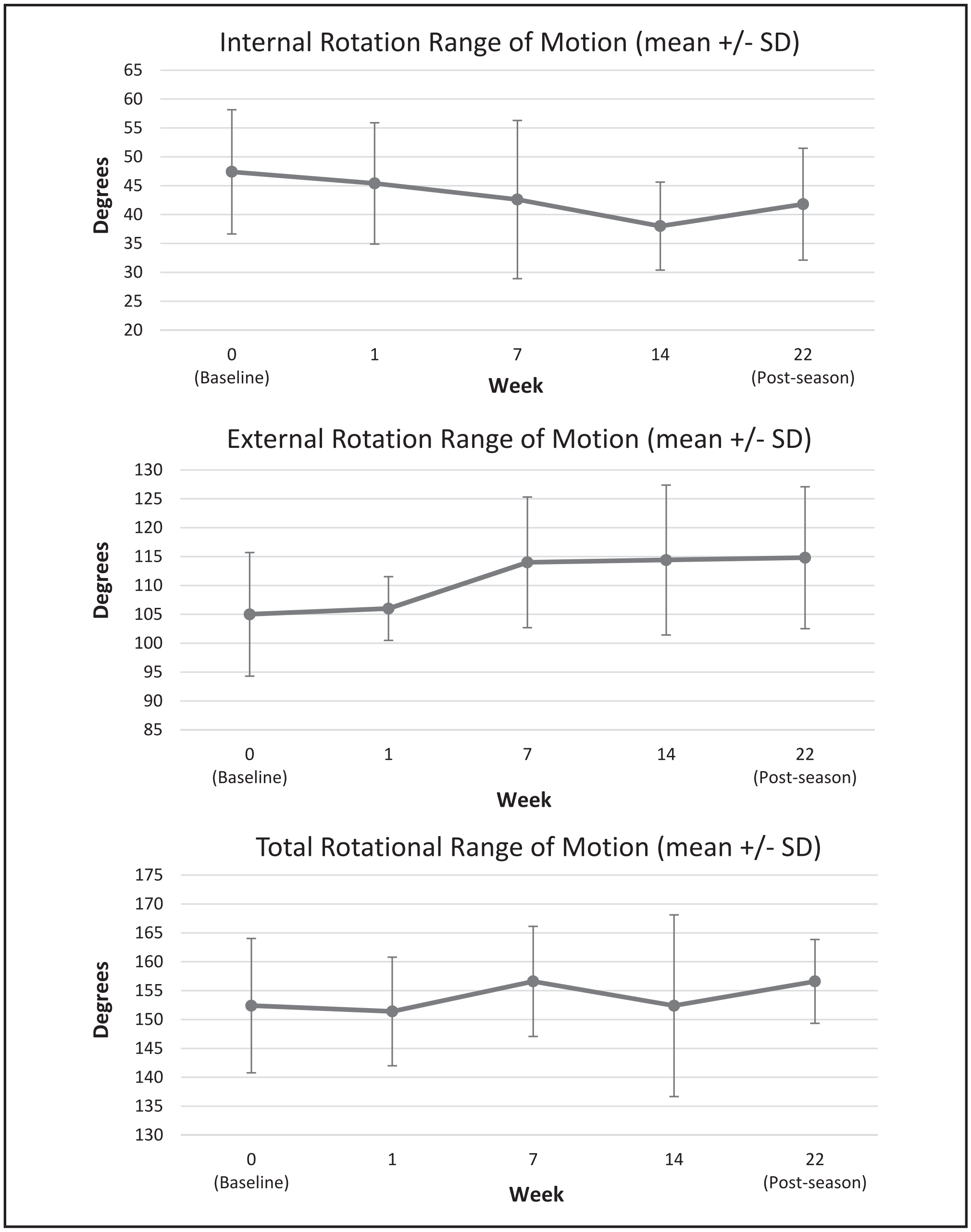


Figure 4. *Dominant Shoulder Range of Motion Measurements.*

games per match.[31] Pitch count recommendations for adolescent baseball athletes include throwing less than 80 pitches per game, and only 30-39 pitches on one day of rest.[10] One may argue that the volleyball spike requires different demands placed upon the shoulder complex as compared to executing a baseball pitch; thus, requiring a different set of guidelines for UE workload. Electromyographic analysis revealed similar patterns of muscle activation in high level volleyball players for the spike and serve, which was also comparable to a baseball pitch and tennis serve during the acceleration and deceleration phases of arm motion.[32] However, different volleyball swings produced various amounts of torque, with the spike producing nearly twice the amount of internal rotation torque as a roll shot.[33] The current study grouped spikes/attacks, roll shots, and serves into the overall swing count, which may be considered a limitation in reporting UE workload. Future investigations may wish to delineate UE workload according to the specific type of overhead activity performed in volleyball athletes.

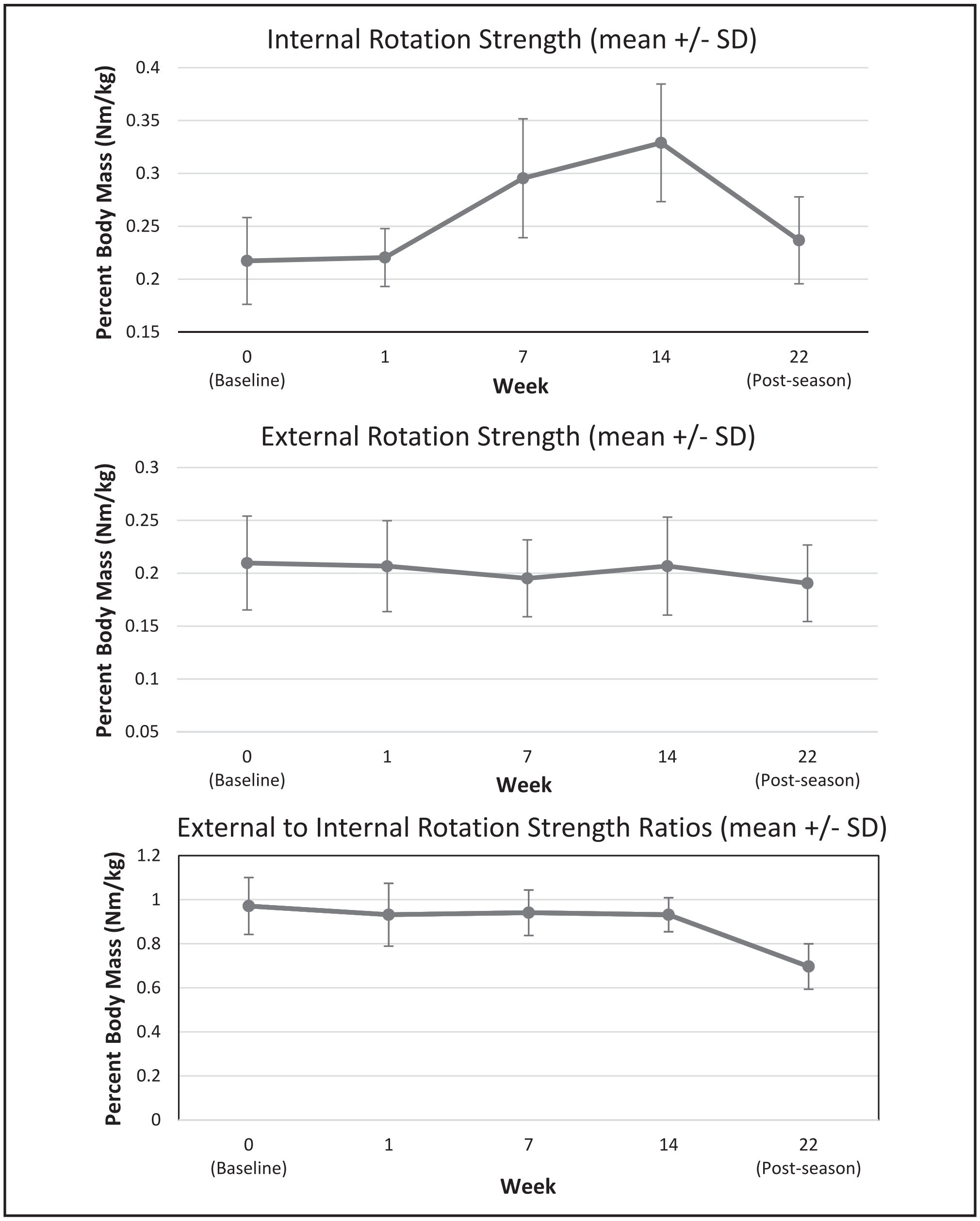


Figure 5. *Dominant Shoulder Strength Measurements.*

Changes in shoulder mobility for volleyball athletes were similar to those seen in other overhead sports with a trend toward decreased IR ROM, and increased ER ROM.[34] The current study is unique, in that these changes are described chronologically. Shoulder mobility adaptations in IR and ER ROM continued throughout the competitive season, but total shoulder ROM remained relatively consistent over time. It was interesting to note that although not statistically significant, changes in IR and ER ROM had not returned to baseline levels after eight weeks of relative rest (self-selected level of activity). Activities performed during this eight-week period were not tracked as part of the study protocol, which may have offered additional insight into ROM changes. Rehabilitation professionals may wish to engage volleyball athletes in an active recovery process to avoid shoulder mobility complications.

Certain patterns have been described for dominant shoulder strength profiles of elite volleyball athletes, which includes increased concentric/eccentric strength of the internal rotators when compared to the nondominant UE.[15] IR strength gains were observed over the course of the competitive season, which was most likely a sport-specific adaptation. Of note, ER strength values did not follow a similar pattern, which raises concern for maintaining appropriate ER:IR strength ratios throughout the season. It was reported that collegiate male baseball pitchers demonstrated mean ER:IR isokinetic strength ratios of 0.7 in the dominant UE,[35] with recommendations for attaining at least a 0.65 ratio.[36] Although the strength ratios reported in the current study were roughly 0.9 throughout the season, a noteworthy decrease in ER:IR strength ratios were observed after eight weeks of rest (0.7). Future research may wish to investigate the relationship between ER:IR strength ratios and UE injury in volleyball athletes. Further, it may be appropriate for rehabilitation professionals to assess shoulder strength ratios upon return from offseason to address strength imbalances in order to inform injury prevention.

LIMITATIONS

The generalizability of the results is primarily limited due to a small sample recruited from a single Midwestern university. Additionally, it is common practice for attacking players to 'fake' a swing, while still carrying out the UE motion, which was not accounted for in this study; thereby, potentially underestimating the true workload for the UE.

The reliability of actual swing count procedures was not determined for this study, which may have impacted perceived swing count accuracy. Wearable technology has recently been investigated for use in assessing jump performance in volleyball athletes,[37] as well as tracking competition load sustained to the lower extremities.[38] Wearable devices may hold promise in tracking UE workload in volleyball athletes with greater accuracy,[39] and would be a logical direction for future research.

CONCLUSIONS

The results of this study indicate that UE swing count estimates by coaching staff demonstrated higher correlation with actual swing counts obtained through video recording as compared to volleyball athlete self-report. This cohort of collegiate volleyball athletes experienced increased shoulder IR strength and ER ROM over a competitive season. Shoulder IR ROM decreased during the first 14 weeks with a large effect size. Some UE performance measures did not return to baseline values, even after an eight-week period of relative rest. Monitoring the progression of UE performance measures and swing count volume may have implications for injury reduction and program development for volleyball athletes.

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